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Redfish Catch Results from the Summer 2007 Survey in Unit 2

Résultats des captures du sébaste à l'issue des relevés de l'été 2007 dans l'unité 2

John McClintock and Michael Teasdale

AMEC Earth & Environmental
A Division of AMEC Americas
133 Crosbie Road
PO Box 13216
St. John's NL A1B 4A5

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ABSTRACT

To enhance the fisheries research database in Unit 2, NAFO Subdiv. 3Pn, 3Ps, 4Vn, and 4Vs, the Groundfish Enterprise Allocation Council (GEAC) has funded redfish surveys during winter 1997, and summers from 1998 to 2001, 2003, 2005, and 2007. These surveys are the only available index of stock condition given the Department of Fisheries and Oceans (DFO) last conducted a Unit 2 redfish survey in 2002 and there are no plans to continue with the DFO surveys. GEAC funded and performed the surveys with scientific guidance from DFO in the design and execution of a stratified random survey and the associated sampling. The data collected during these surveys have been subsequently analyzed on behalf of GEAC and for the additional intent of providing this information to DFO, for their databases and their assessment work. This is the eighth such GEAC redfish survey in Unit 2 following on the previous 1997 to 2005 surveys. The number of sets conducted in the 2007 survey increased by about 40% from previous surveys, in an attempt to reduce the variability/range of uncertainty of results. Catch statistics, length distribution, and stratified analysis estimates of redfish abundance and biomass, and interpretation of results are presented.

The 2007 Unit 2 total redfish biomass estimate is 98 ktonnes which is about 7% greater than the 2005 survey estimate of 92 ktonnes and 20% greater than the 2003 estimate of 82 ktonnes. The total abundance estimate for Unit 2 in 2007 is 336 million (M), an increase of 12% from the 2005 survey estimate of 299 M, and the largest since the 2001 survey estimate of 404 M. In 2007, estimates of 227 M in 3Ps were 2.4 times those from 2005: 3Ps biomass estimates in 2007 were double those of 2005. In the other three Unit 2 subdivisions 2007 abundance and biomass estimates were down compared with the 2005 counterparts. Abundance in 3Pn and 4Vn were each one third of their 2005 estimates, while the 4Vs estimate of 73 M in 2007 was 82% of the 2005 estimate of 89 M. 2007 biomass estimates in 4Vn and 4Vs at 13.4 and 23.0 ktonnes respectively were down by about 25% from 2005. An approach was considered to apportion abundance and biomass estimates based on maturity of the various population components of redfish in Unit 2. This was achieved by considering fish length, and for biomass, a length/weight relationship. Under this approach, in 2007, it was determined that one third of the total abundance estimates and three quarters of the total biomass estimate for Unit 2 are for mature redfish. Utilizing assumptions for illustration, about 68% of the population are *Sebastes fasciatus*, 25% *S. mentella*, and 7% heterozygotes. The 2007 Unit 2 abundance estimate is apportioned as follows: 229 M *S. fasciatus*, 84 M *S. mentella*, and 23 M heterozygotes. These percentages suggest 9% fewer numbers and about a 5% reduction in biomass for mature redfish in 2007 compared with 2005 for which similar approximations were made.

RÉSUMÉ

Pour améliorer la base de données de recherche sur les pêches pour l'unité de gestion 2 (sous-divisions 3Pn, 3Ps, 4Vn et 4Vs de l'OPANO), le Conseil des allocations aux entreprises d'exploitation du poisson de fond (GEAC) a financé des relevés du sébaste effectués à l'hiver 1997 et aux étés 1998 à 2001, 2003, 2005 et 2007. Ces relevés constituent les seuls indices disponibles sur l'état du stock étant donné que le ministère des Pêches et des Océans (MPO) a réalisé son dernier relevé du sébaste pour l'unité 2 en 2002 et qu'il ne prévoit pas poursuivre la réalisation de tels relevés. Le GEAC a financé et réalisé les relevés avec l'aide du MPO, qui a fourni des conseils scientifiques pour la conception et la réalisation d'un relevé aléatoire stratifié et des échantillonnages connexes. Les données ainsi recueillies ont été analysées pour le compte du GEAC et en vue de les transmettre au MPO pour ses bases de données et ses travaux d'évaluation. Ce document aborde le huitième relevé annuel du sébaste dans l'unité de gestion 2, lequel donne suite aux relevés effectués de 1997 à 2005. Le nombre de calées réalisées lors des relevés de 2007 a augmenté d'environ 40 % par rapport aux relevés précédents, dans une tentative de réduire la variabilité/l'intervalle d'incertitude des résultats. Le document présente des statistiques de capture, la distribution des longueurs, des estimations par analyse stratifiée de l'abondance et de la biomasse du sébaste ainsi que l'interprétation des résultats.

La biomasse totale de sébaste estimée pour l'unité de gestion 2 est de 98 kilotonnes, ce qui représente une hausse d'environ 7 % par rapport à l'estimation du relevé de 2005 qui la chiffrait à 92 kilotonnes, et une hausse de 20 % par rapport au relevé de 2003 qui l'estimait à 82 kilotonnes. L'estimation de l'abondance totale pour l'unité 2 en 2007 s'élève à 336 millions (M), une augmentation de 12 % par rapport à l'estimation du relevé de 2005 de 299 M, ce qui en fait l'estimation la plus importante depuis celle du relevé de 2001 qui se chiffrait à 404 M. En 2007, les estimations de 227 M dans 3Ps étaient 2,4 fois celles de 2005 : la biomasse estimée dans 3Ps en 2007 représentait le double de celle de 2005. Dans les trois autres sous-divisions de l'unité 2, les estimations de 2007 pour l'abondance et la biomasse avaient fléchi comparativement aux mêmes estimations pour 2005. L'abondance dans 3Pn et 4Vn représentait un tiers de leurs estimations de 2005, alors que l'abondance estimée à 73 M dans 4Vs en 2007 représentait 82 % de l'estimation de 2005 qui se chiffrait à 89 M. La biomasse de 2007, estimée dans 4Vn et 4Vs à 13,4 et 23,0 kilotonnes respectivement, a baissé d'environ 25 % par rapport à 2005. On a adopté une approche visant à répartir les estimations de l'abondance et de la biomasse en fonction de la maturité des divers constituants de la population de sébaste dans l'unité 2. Ainsi, on a tenu compte de la longueur des poissons et, pour la biomasse, d'un rapport entre la longueur et le poids. En vertu de cette approche, en 2007, il a été déterminé qu'un tiers des estimations de l'abondance totale et que trois quarts des estimations de la biomasse totale pour l'unité 2 visaient les sébastes matures. À partir d'hypothèses pour illustrer cette approche, environ 68 % de la population est constituée de *Sebastes fasciatus*, 25 % de *S. mentella* et 7 % d'individus hétérozygotes. Les estimations de l'abondance en 2007 pour l'unité 2 ont été réparties comme suit : 229 M de *S. fasciatus*, 84 M de *S. mentella* et 23 M d'individus hétérozygotes. De tels pourcentages suggèrent 9 % de chiffres inférieurs et une réduction d'environ 5 % de la biomasse pour les sébastes matures en 2007 comparativement à 2005, année pour laquelle des approximations analogues avaient été faites.

INTRODUCTION

To enhance the fisheries research database in Unit 2, NAFO Subdiv. 3Pn, 3Ps, 4Vn, and 4Vs, the Groundfish Enterprise Allocation Council (GEAC) has funded redfish surveys during winter 1997, and summers 1998 to 2001, 2003, 2005, and 2007. These surveys are the only available index of stock condition given the Department of Fisheries and Oceans (DFO) last conducted a Unit 2 redfish survey in 2002 and there are no plans to continue with the DFO surveys. GEAC funded and performed the surveys with scientific guidance from DFO in the design and execution of a stratified random survey and the associated sampling. The data collected during these surveys have been subsequently analysed on behalf of GEAC and for the additional intent of providing this information to DFO, for their databases and their assessment work. This is the eighth such redfish survey in Unit 2 following on the previous 1997-99 (Power 1999), 2000 (McClintock 2000), 2001 (McClintock 2001), 2003 (McClintock 2003), and 2005 (McClintock 2005) surveys. Under contract to GEAC, AMEC has taken the set catch and length frequencies data logged using the DFO FFS system, and performed a first analysis of the survey results. This document presents these results.

METHODS AND MATERIALS

A Stratified Random survey was carried out in Unit 2 by the *M.V. Cape Ballard*. A summary of the trip is presented below.

TRIP 200: STRATIFIED RANDOM SURVEY

Trip 200 was carried out from 20 September to 7 October 2007. These dates are later than most of the previous surveys that generally ranged from 15 August to 18 September (with the exception of the 1997 Survey which ran from 1 to 12 December). The *Cape Ballard*, also performed the 1998 and 2001 surveys. The *Cape Beaver*, a ship of comparable size and design, performed the 1997, 1999, 2000, 2003, and 2005 surveys. During the trip, length sampling was carried out on board, and the set details and length frequencies data were logged onboard in the DFO FFS system.

Tows of duration 30 minutes were conducted at a speed of 3.5 knots using a commercial Engel 170' bottom trawl with a 105-110 mm lined cod end. All equipment was calibrated and tested prior to the survey. Performance of the trawl was monitored onboard using Scanmar net monitoring equipment. All gear performed well throughout the survey (GEAC 2007). The trawl gear and configuration were identical to those used in the earlier years with the exception that the 1997-99 surveys did not use a liner. Additional trip details are given in GEAC, 2007.

A total of 134 stratified random tow sets were completed successfully, an increase of about 40% from previous surveys. Seven additional sets were unsuccessful. Redfish in Unit 2 are comprised of a complex of three species identified as *Sebastes mentella*, *Sebastes fasciatus* (and heterozygotes, a hybrid) and *Sebastes marinus*. For the analysis, redfish species *S. mentella* and *S. fasciatus* (very similar and difficult to distinguish and together coded as *S. mentella)* were considered: any *S. marinus*, of which there were a few, were ignored. This is consistent with the previous years' analyses. Further discussion of biological redfish population components, specifically abundance and biomass estimates, is provided below.

It is noted that a data entry error in the 2005 survey set catch details was discovered during the preparation of this document. The error had effectively doubled the catch weights but did not

affect the abundance estimates. This error was corrected and the stratified analysis for 2005 was repeated. This document therefore contains revised and significantly different results for 2005 compared with the original presentation (McClintock 2005).

RESULTS AND DISCUSSION

The set details and redfish length frequencies exported from FFS to create ASCII digital data files were provided to AMEC by DFO.

ACON plots of the 2007 spatial distribution of catch weights are presented in Fig. 1a together with results from the other surveys. In 2007, 10 additional sets were fished in five nearshore strata: these catch weights are shown in grey. Figure 1b shows a map illustrating the location of the strata surveyed. Table 1 presents a summary of the redfish set details and catch numbers and weights. All sets were 30 minutes duration with the exception of three sets that ranged from 28 to 33 minutes. All set catches were adjusted to a standard 30 minute tow in the presentation of Table 1 and also in the stratified analysis (see below). The redfish were sampled in 1 cm length groupings and all ratio/percentages of catch measured were applied.

As shown in Fig. 1a, there are fewer larger sets in Subdiv. 3Pn and 4Vn to the north. Catch weights appear generally consistent in 3Ps, while in 4Vs there are smaller catches compared with 2005.

Stratified Random survey analysis was carried out using the DFO stratified analysis STRAP software and applying the French Exclusion Zone around St. Pierre et Miquelon for area calculations. A wingspread of 69 feet was used, consistent with the 1997-2005 analyses. Two STRAP runs were completed: one excluding the 10 extra sets noted above (in strata 295, 296, 298, and 300: the locations of these are shown in the 2007 panel of Fig. 1a) and in this way consistent with the strata surveyed and reported on previously; and one including these five additional strata. It is noted that this number of 119 sets (this excludes the 10 nearshore sets) is 29% greater than 92 sets in 2005, and 43% greater than the average of 83 sets from all years 1997 to 2005.

Table 2 presents mean weight per set and biomass estimates. Figure 2 shows the mean weight per set together with 95% upper and lower confidence limits for the estimate. Consistent with the increased number of sets in 2007, the associated range of uncertainty is noticeably improved compared with 2005 and the earlier years of the survey record. Mean values in 2007 range from 35 kg per tow in 3Pn to 214 kg per tow in 3Ps. In 3Pn, 4Vn, and 4Vs the estimates are from two thirds to 20% of the 2005 estimates: in 3Ps the estimate is almost double.

In terms of biomass, the following observations can be made:

- Overall, in Unit 2, the total biomass estimate for 2007 is 98 ktonnes, comparable to the 2005 estimate of 92 ktonnes, and in keeping with the 2003 estimate of 82 ktonnes.
- The total abundance estimate of 336 M in 2007 is about 12% larger than the 299 M estimated in 2005, and 90% greater than the 2003 estimate of 175 M.
- In 3Pn, the biomass estimate of 2.5 ktonnes is the smallest of any survey year: the next smallest being 4.9 ktonnes in 2001.

- In 3Ps, the biomass estimate of 59.5 ktonnes is twice the 2005 survey estimate of 30.2 ktonnes.

- In 4Vn, the 2007 biomass estimate of 13.4 ktonnes is about 74% of the 2005 estimate of 18.4 ktonnes, and is the smallest of all survey years, slightly less than the 2001 and 2003 estimates of 15.8 ktonnes.

- In 4Vs, the biomass estimate of 23 ktonnes is 79% of the 2005 estimate of 29.3 ktonnes and is the lowest estimate since the 1999 estimate of 19.3 ktonnes.

Figures 3a-3c present 3D charts of the Table 2 abundance estimates. Figure 3a shows mean weight per tow by subdivision and by year. Figure 3b shows the total biomass estimate by subdivision and by year. Figure 3c shows the total abundance estimate by subdivision and by year.

Figure 4 shows mean weight per tow by stratum for each year. On the x-axis the subdivision, stratum number, and stratum depth range are noted. The stratum are shown left to right for the four subdivisions, and within each subdivision the stratum are listed from shallowest to deepest (as in Table 2). Depth ranges of stratum that are the same as their neighbour listed on their left are left blank. The greatest contribution is from stratum 708 by almost an order of magnitude more than any other stratum.

There were five strata in 2007 which did not factor into the STRAP estimates since only one set was sampled: strata 318, 417, 705, 707, and 709.

Figure 5 presents the redfish survey abundance index at length values, by sex, for the 1997-2007 Unit 2 surveys.

Figure 6 presents the male and female abundance distributions for all eight years together.

Figure 7 presents the length distributions for each subdivision. The mean number per standard tow is presented. Figure 8 presents the same information, arranged with all years together in a graph for each subdivision.

Table 3 presents the mean weight per set and biomass estimates for Subdiv. 3Ps, repeating the values presented in Table 2 but with 3Ps estimates that include the five additional strata nearshore. Figure 9 similarly compares the length distributions for 3Ps indicating the incremental contribution from the nearshore sets is primarily at smaller lengths of about 17 cm or less.

As part of this survey analysis, a method was put forward to apportion the GEAC 2007 abundance and biomass estimates into species components for illustrative purposes. This is presented in Appendix A.

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The authors thank Don Power, DFO, for STRAP run support, and especially his assistance in the survey analysis including suggestions for use of length thresholds for discriminating redfish species component populations and application of a length-weight relationship to abundance estimates to yield estimates of biomass. Thanks are similarly extended to Jean-Marie Sévigny, DFO, for providing indices of abundance of total and mature *S. fasciatus*, *S. mentella* and heterozygotes in Unit 2.

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Table 1. Summary of redfish catches for stratified random survey sets, Unit 2, 20 September-07 October 2007.

Cape Ballard (vessel code 48) Trip 200							Set Location		Redfish		Set	Tow	Redfish
Set	Month	Day	StrLin	Division	Unit Area	Depth (m)	Latitude (deg N)	Longitude (deg W)	Catch ** # of Fish	Catch ** Weight (kg)	Duration (min)	Distance (n.mi.)	Mean Weight (kg)
7	9	21	709	3Ps	M33	498	44.83	55.66	1529	709	30	1.7	0.46
8	9	21	711	3Ps	L33	451	44.86	56.07	414	188	30	1.8	0.45
9	9	21	398	4Vs	L33	385	44.69	56.42	2290	777	30	1.7	0.34
10	9	21	398	4Vs	L33	396	44.79	56.51	116	41	30	1.8	0.36
11	9	21	708	3Ps	M33	469	44.84	55.69	5499	2249	30	1.8	0.41
12	9	22	707	3Ps	N32	321	45.00	54.92	3892	1485	30	1.7	0.38
13	9	22	708	3Ps	N32	445	45.04	54.56	11764	3678	30	1.6	0.31
14	9	22	318	3Ps	M33	241	44.96	55.60	82	23	30	1.8	0.28
15	9	22	398	4Vs	L33	394	44.68	56.54	91	25	30	1.8	0.28
16	9	22	398	4Vs	L33	414	44.73	56.75	371	212	30	1.8	0.57
17	9	22	398	4Vs	L33	425	44.74	56.93	369	213	30	1.8	0.58
18	9	23	399	4Vs	K33	423	44.68	57.08	283	155	31	1.8	0.55
19	9	23	398	4Vs	L33	404	44.59	56.83	235	138	30	1.8	0.59
20	9	23	399	4Vs	K33	418	44.60	57.00	1596	653	30	1.8	0.41
21	9	23	399	4Vs	K33	421	44.69	57.09	366	225	30	1.8	0.62
22	9	23	446	4Vs	K33	321	44.59	57.18	2332	367	30	1.8	0.16
23	9	23	451	4Vs	K34	258	44.30	57.80	1098	302	30	1.8	0.28
24	9	24	451	4Vs	J34	254	44.04	58.50	376	78	30	1.8	0.21
25	9	24	452	4Vs	H34	219	44.16	59.02	1176	57	30	1.7	0.05
27	9	24	452	4Vs	H34	255	44.22	59.35	1187	130	30	1.8	0.11
28	9	24	452	4Vs	H34	239	44.32	59.44	509	23	30	1.8	0.04
29	9	25	446	4Vs	K32	266	45.20	57.63	0	0	30	1.8	
30	9	25	400	4Vs	K32	453	45.23	57.41	37	27	30	1.8	0.72
31	9	25	397	4Vs	K32	452	45.19	57.29	98	68	30	1.8	0.70
32	9	25	399	4Vs	K32	450	45.10	57.31	81	67	30	1.8	0.83
33	9	25	398	4Vs	L32	412	45.01	56.67	91	54	30	1.8	0.60
34	9	26	706	3Ps	L32	336	45.07	56.32	264	27	30	1.8	0.10
35	9	26	711	3Ps	L32	404	45.12	56.62	139	74	30	1.7	0.53
36	9	26	316	3Ps	L32	227	45.21	56.31	38	9	30	1.8	0.22
37	9	26	711	3Ps	L32	399	45.23	56.66	131	79	30	1.7	0.60
38	9	26	711	3Ps	L32	399	45.32	56.74	176	115	30	1.8	0.66
39	9	26	711	3Ps	L32	393	45.44	56.75	129	108	30	1.8	0.83
40	9	26	706	3Ps	L32	344	45.44	56.58	201	91	30	1.8	0.45
41	9	26	712	3Ps	L31	414	45.68	56.98	140	77	30	1.8	0.55
43	9	27	316	3Ps	L31	228	45.76	56.76	235	25	30	1.8	0.10
44	9	27	706	3Ps	L31	333	45.75	56.85	338	68	30	1.8	0.20
45	9	27	712	3Ps	K31	405	45.84	57.08	537	316	30	1.8	0.59
46	9	27	706	3Ps	L31	324	45.92	56.01	294	70	30	1.8	0.24
47	9	27	712	3Ps	K31	416	45.95	57.20	201	124	30	1.8	0.62
48	9	27	313	3Ps	K30	223	46.16	57.18	7265	624	30	1.8	0.09
49	9	27	715	3Ps	K30	321	46.32	57.39	287	113	30	1.8	0.39
50	9	27	713	3Ps	K30	425	46.49	57.65	51	36	30	1.8	0.70
51	9	27	313	3Ps	K29	254	46.58	57.49	31	18	30	1.8	0.59
52	9	27	705	3Ps	K29	330	46.54	57.56	245	146	30	1.8	0.60
53	9	28	715	3Ps	K29	331	46.64	57.64	273	119	30	1.8	0.43
54	9	28	714	3Ps	K29	453	46.57	57.79	91	59	30	1.8	0.65
55	9	28	714	3Ps	K29	437	46.70	57.87	102	70	30	1.8	0.68
56	9	28	716	3Ps	K29	325	46.76	57.65	440	200	30	1.8	0.45
57	9	28	716	3Ps	K29	313	46.80	57.46	3508	435	30	1.8	0.12
58	9	28	309	3Ps	K29	249	46.91	57.70	443	122	30	1.8	0.28
59	9	28	310	3Ps	K29	222	46.93	57.10	1536	114	30	1.8	0.07
60	9	28	310	3Ps	L30	237	46.01	56.96	1294	95	30	1.8	0.07
61	9	28	716	3Ps	K28	301	47.10	57.96	383	169	30	1.8	0.44
62	9	29	716	3Ps	L28	312	47.12	56.85	418	311	30	1.8	0.74
63	9	29	298	3Ps	L28	250	47.14	56.68	15785	1147	30	1.7	0.07
64	9	29	298	3Ps	L28	262	47.29	56.43	8243	870	30	1.8	0.11
65	9	29	299	3Ps	L28	361	47.21	56.75	824	591	33	1.8	0.72
66	9	29	295	3Ps	L28	234	47.09	56.01	29	22	30	1.8	0.76
67	9	29	296	3Ps	M28	347	47.39	55.51	0	0	30	1.8	
68	9	29	295	3Ps	M28	249	47.48	55.24	57	26	30	1.7	0.46
69	9	30	296	3Ps	M27	343	47.57	55.23	54	28	28	1.7	0.51
70	9	30	299	3Ps	L28	308	47.43	56.40	921	754	30	1.7	0.82
72	9	30	300	3Ps	L28	235	47.49	56.95	353	74	30	1.8	0.21
73	9	30	300	3Ps	L28	237	47.49	56.90	578	67	30	1.8	0.12
74	9	30	309	3Ps	K28	230	47.30	57.21	617	66	30	1.8	0.11
75	9	30	306	3Ps	K28	236	47.40	57.60	631	31	30	1.8	0.05
76	9	30	306	3Ps	K28	212	47.22	57.96	6892	327	30	1.8	0.05

Table 1 (Cont'd.)

Set	Month	Day	StrLin	Division	Unit Area	Depth (m)	Latitude (deg N)	Longitude (deg W)	Catch ** # of Fish	Catch ** Weight (kg)	Duration (min)	Distance (n.mi.)	Mean Weight (kg)
77	10	1	306	3Ps	J28	230	47.22	58.17	456	23	30	1.8	0.05
78	10	1	303	3Pn	K28	230	47.49	57.78	2114	198	30	1.8	0.09
79	10	1	303	3Pn	J28	232	47.44	58.09	285	23	30	1.7	0.08
80	10	1	303	3Pn	J27	240	47.53	58.17	288	41	30	1.7	0.14
81	10	1	303	3Pn	J28	232	47.43	58.15	66	8	30	1.8	0.13
82	10	1	303	3Pn	J28	206	47.33	58.64	31	4	30	1.9	0.14
83	10	1	304	3Pn	J28	306	47.34	58.78	8	7	30	1.8	0.91
84	10	1	305	3Pn	J28	413	47.26	58.80	59	30	30	1.7	0.50
85	10	1	304	3Pn	J28	342	47.37	58.88	64	17	30	1.8	0.27
86	10	1	305	3Pn	H28	391	47.36	59.02	25	17	30	1.8	0.69
87	10	1	305	3Pn	H28	436	47.41	59.32	21	14	30	1.8	0.67
88	10	2	415	4Vn	H27	508	47.57	59.71	23	17	30	1.7	0.74
89	10	2	415	4Vn	H27	517	47.58	59.86	24	18	30	1.7	0.74
90	10	2	415	4Vn	H27	514	47.54	59.99	16	14	30	1.8	0.87
91	10	2	415	4Vn	G27	518	47.63	60.11	18	14	30	1.7	0.75
92	10	2	415	4Vn	G27	500	47.58	60.13	35	27	30	1.7	0.77
93	10	2	415	4Vn	H28	481	47.43	59.63	16	13	30	1.8	0.84
94	10	2	305	3Pn	H28	467	47.36	59.43	16	13	30	1.8	0.83
95	10	2	305	3Pn	H27	451	47.86	59.26	52	37	30	1.8	0.72
96	10	2	415	4Vn	H28	465	47.24	59.42	47	38	30	1.8	0.81
97	10	2	415	4Vn	H28	469	47.30	59.48	20	17	30	1.8	0.84
98	10	2	415	4Vn	H28	464	47.24	59.79	13	11	30	1.8	0.81
99	10	3	415	4Vn	H28	452	47.16	59.77	9	8	30	1.8	0.84
100	10	3	416	4Vn	H28	256	47.06	59.92	89	69	30	1.8	0.78
101	10	3	416	4Vn	H29	350	46.87	59.70	56	41	30	1.8	0.73
102	10	3	415	4Vn	H28	447	47.03	59.48	43	33	30	1.8	0.77
103	10	3	415	4Vn	H28	449	47.01	59.30	26	18	30	1.8	0.69
104	10	3	415	4Vn	H29	459	46.99	59.14	70	51	30	1.8	0.72
105	10	3	305	3Pn	J28	442	47.02	58.91	52	36	30	1.8	0.69
106	10	3	415	4Vn	J29	441	46.91	58.97	64	46	30	1.8	0.72
107	10	3	415	4Vn	J29	433	46.78	58.88	78	42	30	1.8	0.54
108	10	3	415	4Vn	J29	420	46.71	58.78	109	84	30	1.8	0.77
109	10	3	415	4Vn	H29	434	46.72	59.01	54	43	30	1.8	0.79
110	10	4	415	4Vn	H29	441	46.88	59.30	25	19	30	1.8	0.77
111	10	4	415	4Vn	H29	437	46.81	59.34	17	12	30	1.8	0.70
112	10	4	416	4Vn	H29	349	46.76	59.56	63	45	30	1.8	0.71
113	10	4	417	4Vn	H29	238	46.60	59.47	548	312	30	1.7	0.57
114	10	4	417	4Vn	H30	245	46.48	59.26	134	101	30	1.8	0.75
115	10	4	416	4Vn	H30	361	46.50	59.09	125	93	30	1.8	0.74
116	10	4	416	4Vn	H30	321	46.40	59.01	43	29	30	1.8	0.67
117	10	4	415	4Vn	J29	444	46.52	58.46	43	33	30	1.7	0.75
118	10	4	714	3Ps	J29	461	46.67	58.42	40	29	30	1.7	0.72
119	10	4	714	3Ps	J29	463	46.79	58.22	44	34	30	1.8	0.77
120	10	5	714	3Ps	J29	466	46.88	58.30	25	18	30	1.8	0.72
121	10	5	714	3Ps	J29	452	46.88	58.47	56	42	30	1.8	0.75
122	10	5	714	3Ps	J29	435	46.93	58.59	89	62	30	1.8	0.70
123	10	5	715	3Ps	J28	334	47.00	58.10	53	37	30	1.8	0.70
124	10	5	714	3Ps	J29	463	46.69	58.07	49	33	30	1.8	0.68
125	10	5	714	3Ps	J29	469	46.56	58.05	78	59	30	1.8	0.76
126	10	5	713	3Ps	J30	461	46.33	58.04	101	70	30	1.8	0.69
127	10	5	713	3Ps	K30	478	46.23	57.99	256	183	30	1.8	0.71
128	10	5	415	4Vn	J30	467	46.16	58.06	123	78	30	1.8	0.63
129	10	5	415	4Vn	J30	418	46.09	58.22	213	144	30	1.8	0.68
130	10	6	415	4Vn	J30	416	46.04	58.19	380	256	30	1.8	0.67
131	10	6	417	3Ps	J31	242	45.81	58.14	231	34	30	1.8	0.15
132	10	6	446	4Vs	J31	327	45.73	58.01	94	59	30	1.8	0.63
133	10	6	400	4Vs	K31	455	45.63	57.72	180	130	30	1.8	0.72
134	10	6	415	4Vn	K31	462	45.72	57.54	381	257	30	1.8	0.68
135	10	6	397	4Vs	K31	459	45.51	57.51	150	99	30	1.8	0.66
136	10	6	397	4Vs	K32	45[illegible]	45.43	57.50	75	50	30	1.8	0.67
137	10	6	397	4Vs	K32	443	45.37	57.17	242	160	30	1.7	0.66
138	10	6	712	3Ps	K31	433	45.62	57.19	467	306	30	1.8	0.65
139	10	7	712	3Ps	K31	444	45.61	57.30	2160	1531	30	1.8	0.71
140	10	7	712	3Ps	K31	453	45.74	57.38	352	233	30	1.7	0.66
141	10	7	713	3Ps	K30	464	46.31	57.64	59	40	30	1.8	0.68
142	10	7	713	3Ps	K30	460	46.22	57.67	91	61	30	1.8	0.67
143	10	7	713	3Ps	K30	470	46.16	57.67	168	118	30	1.8	0.71
								Maximum	15784.9	3678.5	33.0	1.9	0.9
								Minimum	0.0	0.0	28.0	1.6	0.0
								Mean	757.9	191.1	30.0	1.8	0.5
								Median	130.1	63.9	30.0	1.8	0.6
								Standard Error	15.5	3.2	0.0	0.0	0.0
								Total	101561.3	25601.2	4022.0	238.9	

** set catch numbers and weights adjusted to a standard 30 minute tow at 3.5 knots. (Scale by 1.8/distance towed)

Table 2. Mean weight (kg) of redfish caught per standard 30 minute tow and survey biomass in UNIT2 during GEAC surveys from 1997 to 2007. (Numbers in brackets are successful sets, "-" indicates strata not sampled, "x" indicates strata with less than 2 sets). Total abundance estimates are noted at the bottom of the table.

STRATUM	Depth Range (m)	Area sq. n. mi.	1997 Dec 1-12	1998 Aug16-23	1999 Aug31-Sep9	2000 Aug15-23	2001 Sep10-18	2003 Aug28-Sep5	2005 Aug17-26	2007 Sep20-Oct7
3Pn										
303	185-274	554	187.8 (2)	551.2 (2)	271.4 (3)	50.8 (3)	89.7 (3)	195.7 (4)	244.6 (3)	54.9 (5)
304	275-366	151	194.2 (2)	49.8 (2)	36.3 (2)	388.5 (2)	27.5 (2)	79.7 (2)	63.0 (2)	12.3 (2)
305	367+	733	27.2 (2)	76.8 (2)	36.7 (4)	58.8 (4)	61.9 (4)	146.4 (3)	104.9 (5)	24.5 (6)
Upper			628.3	982.8	443.2	175.8	147.5	211.2	447.0	74.4
Mean			108.4	126.7	157.7	90.4	69.3	108.6	200.2	35.0
Lower			-411.6	-729.4	-127.8	5.0	-9.1	-33.0	-46.6	-4.4
Biomass (metric tons)			**7630**	**8918**	**11100**	**6362**	**4858**	**7646**	**14092**	**2464**
3Ps										
306	185-274	363	0.1 (2)	11.7 (2)	9.2 (2)	54.5 (2)	105.8 (2)	61.5 (2)	25.5 (2)	126.9 (3)
309	185-274	256	10.7 (2)	106.4 (2)	411.0 (2)	149.0 (2)	249.9 (2)	98.5 (2)	x (1)	93.8 (2)
310	185-274	170	-	20.7 (2)	6.4 (2)	70.5 (2)	42.9 (2)	70.9 (2)	x (1)	104.9 (2)
313	185-274	165	10.6 (2)	10.8 (2)	5.0 (2)	33.0 (2)	40.8 (2)	21.0 (2)	x (1)	321.2 (2)
316	185-274	193	40.6 (2)	68.3 (2)	19.1 (2)	104.5 (2)	66.2 (2)	64.8 (2)	256.7 (2)	16.8 (2)
318	185-274	129	1697.5 (2)	-	173.6 (2)	71.0 (2)	47.1 (2)	344.1 (2)	416.5 (2)	-
705	275-366	195	105.4 (2)	29.1 (2)	32.5 (2)	56.6 (2)	18.5 (2)	38.6 (2)	40.2 (2)	-
706	275-366	476	-	97.4 (2)	54.3 (3)	49.3 (3)	120.4 (3)	84.1 (2)	65.5 (3)	63.8 (4)
707	275-366	74	707.3 (2)	931.2 (2)	202.0 (2)	3753.5 (2)	169.4 (2)	721.1 (2)	328.9 (2)	-
715	275-366	128	204.3 (2)	397.1 (2)	249.5 (2)	108.0 (2)	446.1 (2)	45.0 (2)	51.0 (2)	89.6 (3)
716	275-366	539	-	195.4 (2)	88.1 (3)	80.0 (3)	163.4 (3)	28.2 (2)	84.7 (3)	278.7 (4)
708	367-549	126	1267.6 (2)	995.3 (2)	1906.5 (2)	1104.5 (2)	362.2 (2)	238.5 (2)	719.8 (2)	2963.6 (2)
711	367-549	593	482.1 (2)	173.1 (2)	75.0 (3)	172.3 (3)	191.3 (3)	96.7 (3)	144.9 (4)	112.9 (5)
712	367-549	731	74.5 (3)	160.4 (2)	64.9 (4)	186.8 (4)	115.4 (4)	91.4 (4)	98.0 (4)	431.0 (6)
713	367-549	851	1285.5 (4)	31.1 (3)	123.1 (5)	113.6 (5)	43.2 (5)	67.1 (5)	86.2 (5)	84.7 (6)
714	367-549	1047	236.2 (3)	312.4 (3)	99.3 (6)	84.7 (6)	63.0 (6)	28.5 (6)	58.0 (6)	45.2 (9)
709	550-731	147	-	-	-	-	-	-	-	-
Upper			993.1	267.4	552.2	184.2	162.6	108.2	155.1	297.9
Mean			444.4	173.3	135.5	127.6	117.5	80.3	113.2	214.1
Lower			-104.2	79.2	-281.2	71.0	72.3	52.3	71.4	130.4
Biomass (metric tons)			**106329**	**50412**	**40273**	**37916**	**34919**	**23853**	**30161**	**19463**
4Vn										
417	185-274	387	17.9 (2)	347.6 (2)	332.1 (2)	109.5 (2)	85.8 (2)	91.6 (19)	x (1)	206.6 (2)
416	275-366	671	73.7 (2)	247.5 (2)	118.6 (4)	83.8 (4)	134.7 (4)	83.3 (4)	253.2 (3)	55.3 (5)
415	367-532	2915	416.7 (7)	147.4 (8)	92.5 (16)	105.5 (16)	68.9 (15)	76.9 (2)	81.9 (19)	53.8 (24)
Upper			1010.2	648.2	145.1	287.5	122.1	107.9	199.4	110.0
Mean			319.9	382.9	120.3	188.2	81.7	55.0	104.6	63.0
Lower			-370.2	117.6	95.4	48.9	41.2	81.5	10.8	29.0
Biomass (metric tons)			**62219**	**74474**	**23391**	**32714**	**15881**	**15641**	**18358**	**13412**
4Vs										
446	185-366	313	32.4 (2)	3550.8 (2)	-	542.5 (2)	176.8 (2)	19.1 (2)	290.01 (2)	142.9 (3)
451	185-366	147	1985.1 (3)	-	-	96.0 (2)	1012.2 (2)	1354.5 (2)	255.39 (2)	186.4 (2)
452	185-366	345	-	-	-	-	-	-	-	89.9 (3)
397	367-549	640	1403.5 (3)	279.0 (2)	106.2 (2)	1003.7 (3)	76.9 (2)	220.6 (3)	110.7 (3)	34.2 (4)
398	367-549	833	51.1 (4)	558.4 (3)	320.8 (3)	258.7 (6)	240.4 (4)	154.0 (5)	197.1 (6)	208.8 (7)
399	367-549	465	56.3 (3)	132.4 (2)	97.3 (2)	1378.3 (2)	2443.4 (2)	443.6 (3)	500.5 (3)	215.2 (4)
400	367-549	270	36.5 (2)	78.4 (2)	93.4 (2)	138.3 (2)	67.4 (2)	60.8 (2)	62 (2)	79.2 (2)
468	367-549	148	1077.6 (2)	-	-	1796.0 (2)	1051.2 (2)	235.1 (2)	x (1)	-
Total # Sets			66	61	64	64	63	63	62	119
Upper			828.9	8804.9	357.5	1924.1	2050.4	514.7	690.7	246.3
Mean			478.5	747.6	187.0	692.1	643.7	287.6	233.2	161.5
Lower			128.1	-5109.7	17.1	-540.0	-762.9	8.5	-224.3	76.9
Biomass (metric tons)			**63619**	**88601**	**19329**	**92020**	**85593**	**34152**	**29315**	**23027**
TOTAL GEAC SURVEY BIOMASS			**239797**	**222405**	**94093**	**169012**	**141251**	**82122**	**91926**	**98367**
TOTAL ABUNDANCE (millions)			***486***	***497***	***182***	***318***	***404***	***175***	***299***	***336***

[1] 2005 estimates are updated from original CSAS Research Document 2006/079. see text

Table 3. Mean weight (kg) of redfish caught per standard 30 minute tow and survey biomass in 3Ps during 2007 GEAC surveys comparing a dataset with the classic strata and with all strata sampled. Total abundance estimates are noted at the bottom of the table.

STRATUM	2007	2007+Extra Sets
3Ps		
306	126.9 (3)	126.9 (3)
309	93.81 (2)	93.81 (2)
310	104.92 (2)	104.92 (2)
313	321.18 (2)	321.18 (2)
316	16.59 (2)	16.59 (2)
318	-	-
705	-	-
706	63.84 (4)	63.84 (4)
707	-	-
715	89.64 (3)	89.64 (3)
716	278.71 (4)	278.71 (4)
708	2963.55 (2)	2963.55 (2)
711	112.85 (5)	112.85 (5)
712	430.97 (6)	430.97 (6)
713	84.73 (6)	84.73 (6)
714	45.17 (9)	45.17 (9)
295	-	24.2 (2)
296	-	13.76 (2)
298	-	1008.71 (2)
299	-	672.54 (2)
300	-	70.39 (2)
Upper	297.8	309.89
Mean	214.1	236.65
Lower	130.4	163.42
Biomass (metric tons)	**59463**	**75931**

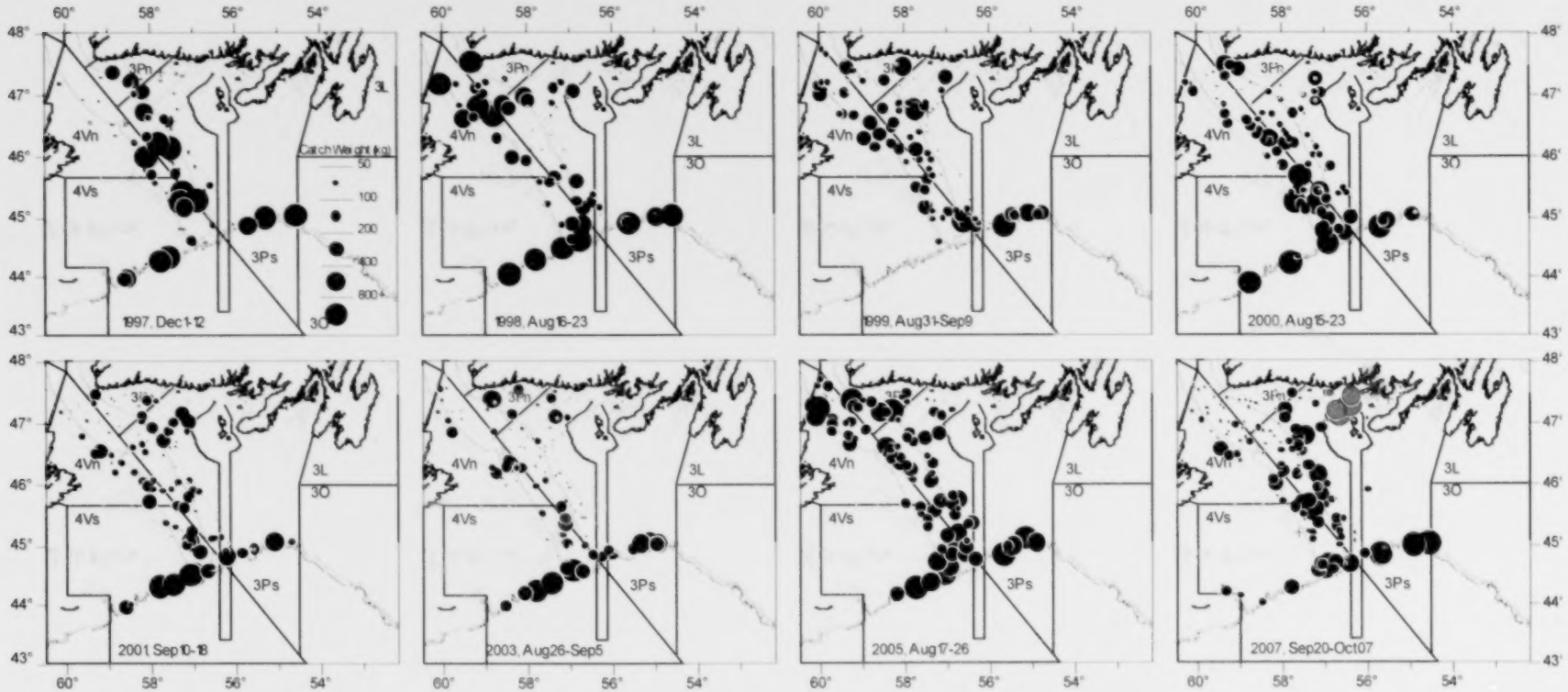


Figure 1a. Redfish catch weight distribution from stratified random surveys, Unit 2, 1997-2007 (200, 400, and 800 m depth contours are shown). A '+' indicates a tow with no redfish caught.

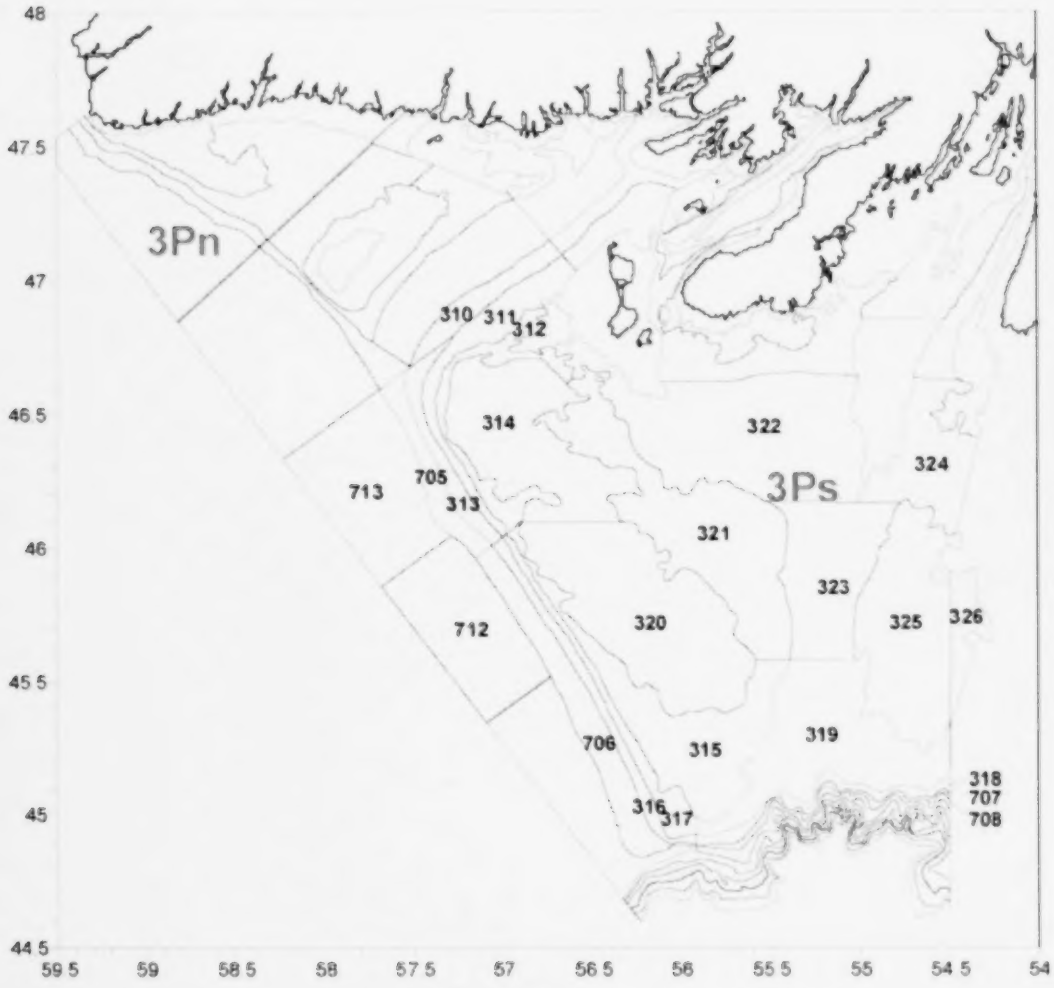
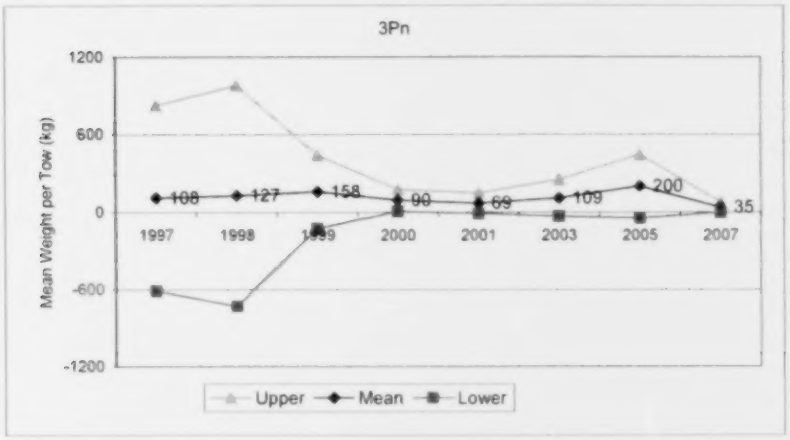
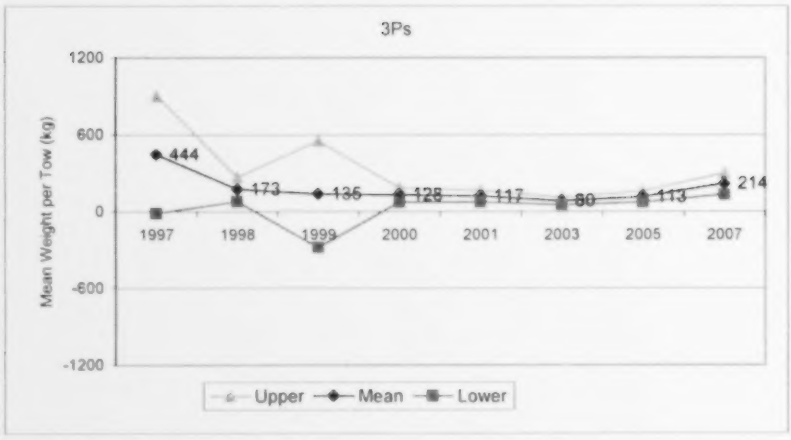
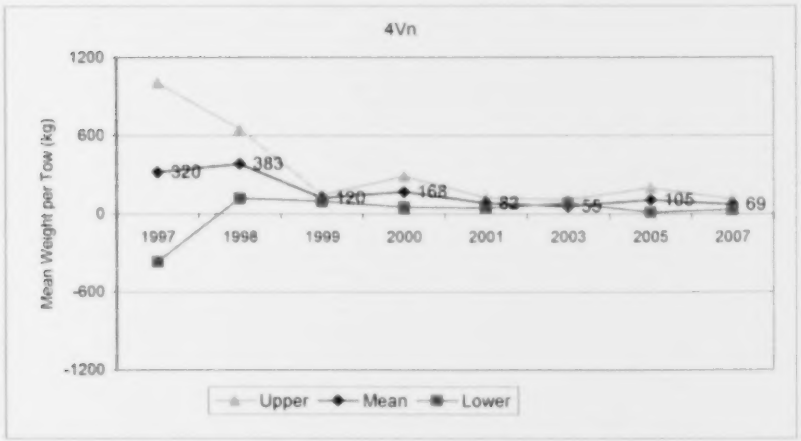


Figure 1b. Stratum boundaries within Unit 2.







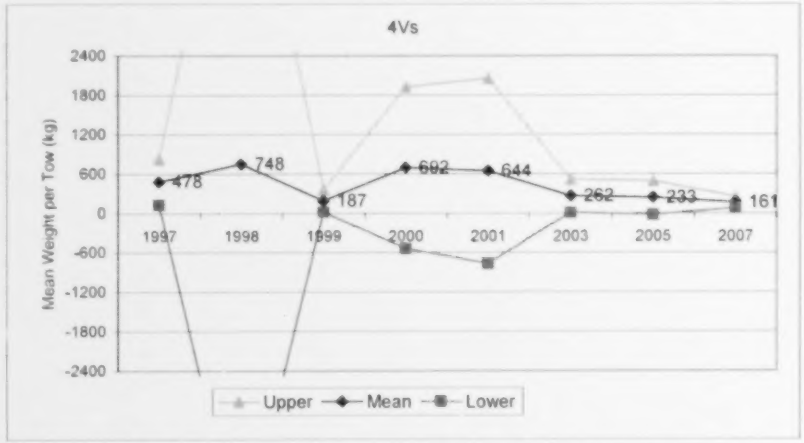


Figure 2. Mean weight (kg) of redfish caught per standard 30 minute tow, from GEAC Unit 2 surveys from 1997 to 2007. Ninety-five percent upper and lower confidence limits are also shown. Note different scale for 4Vs.

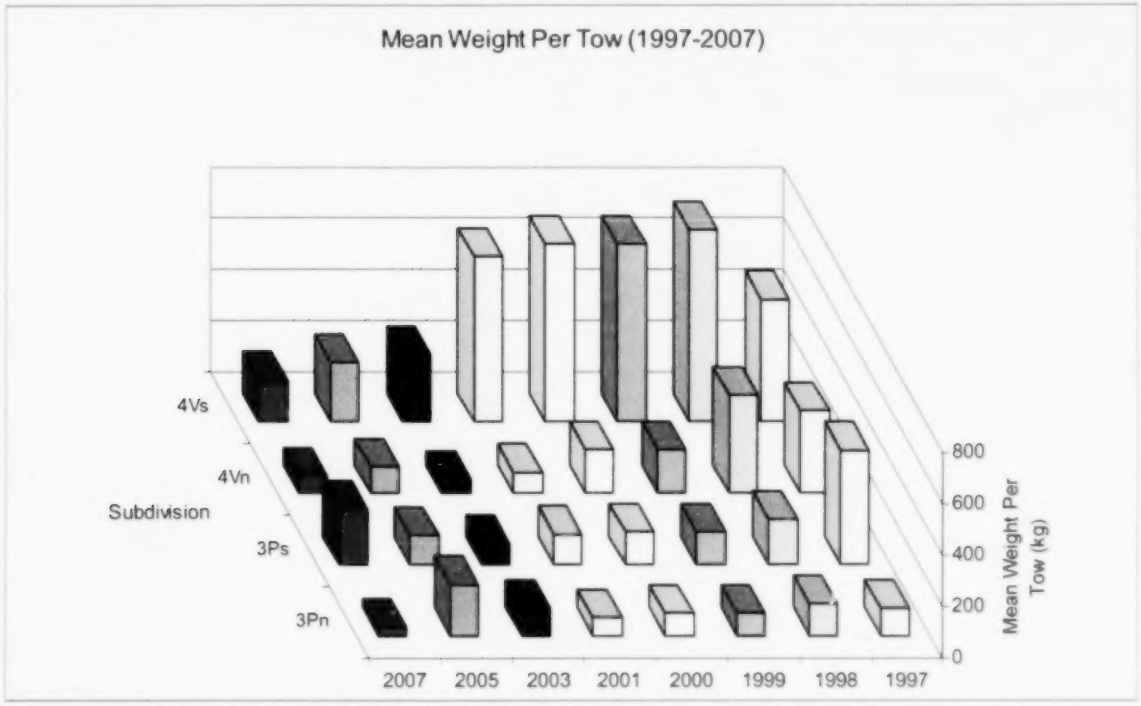


Figure 3a. Catch totals of mean weight per tow by year and subdivision.

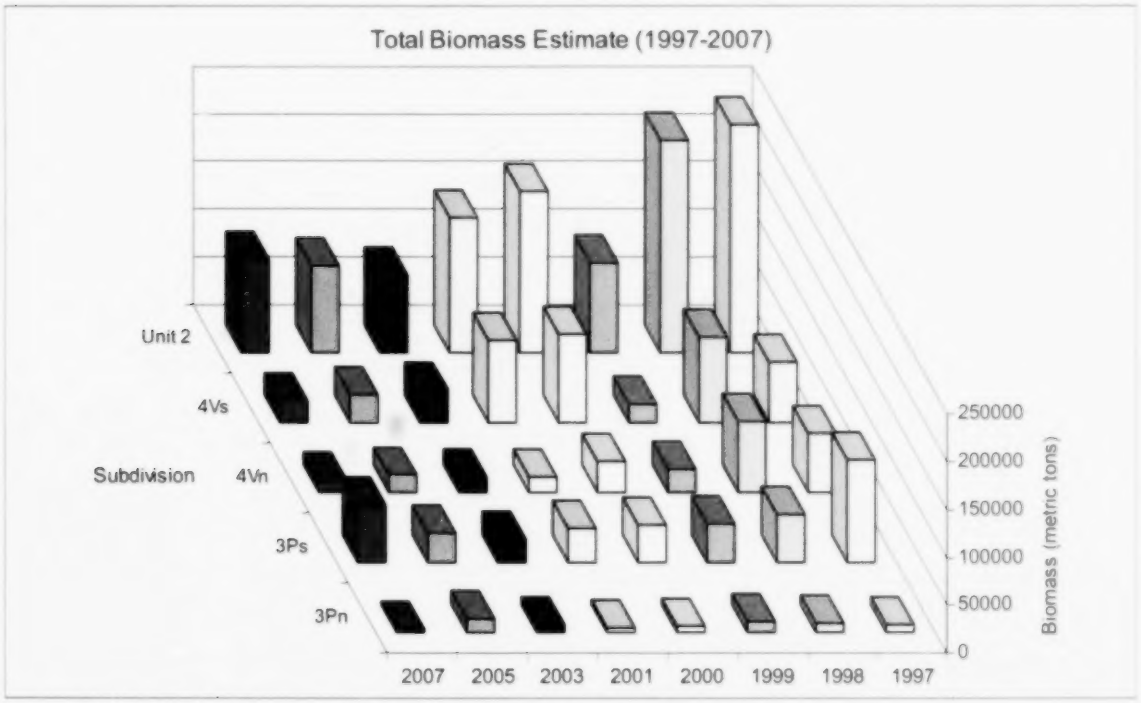


Figure 3b. Catch totals of total biomass estimate by year and subdivision.

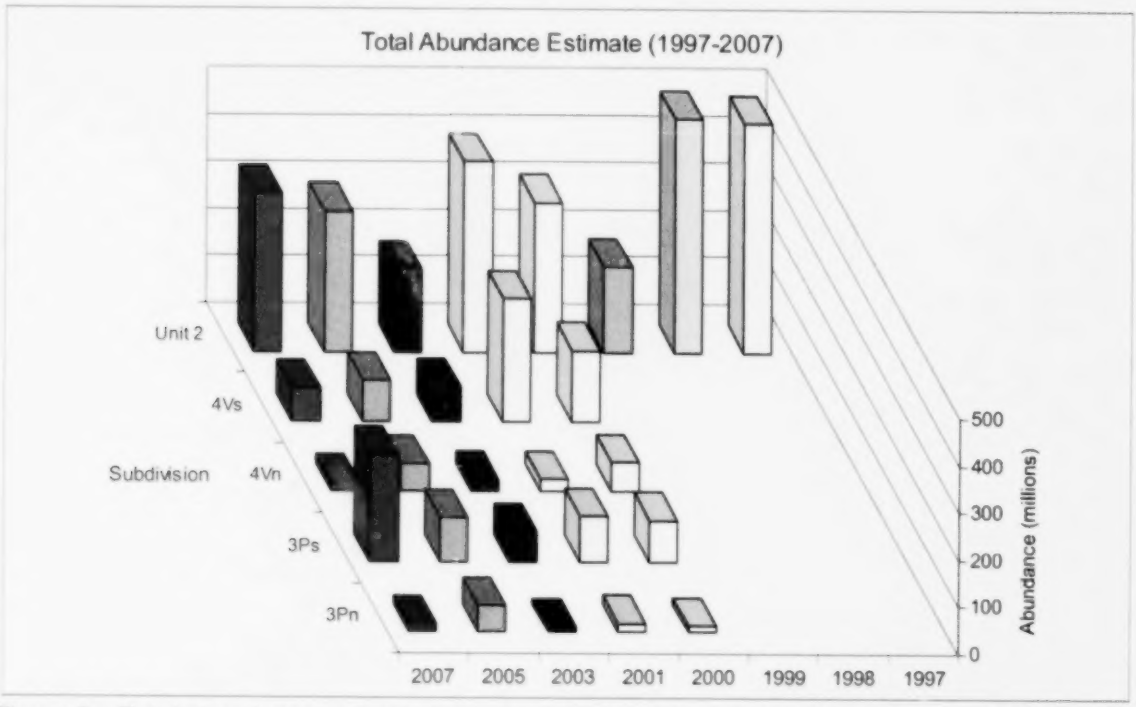


Figure 3c. Total abundance estimate by year and subdivision. Subdivision totals for 1997-99 not available for this document.

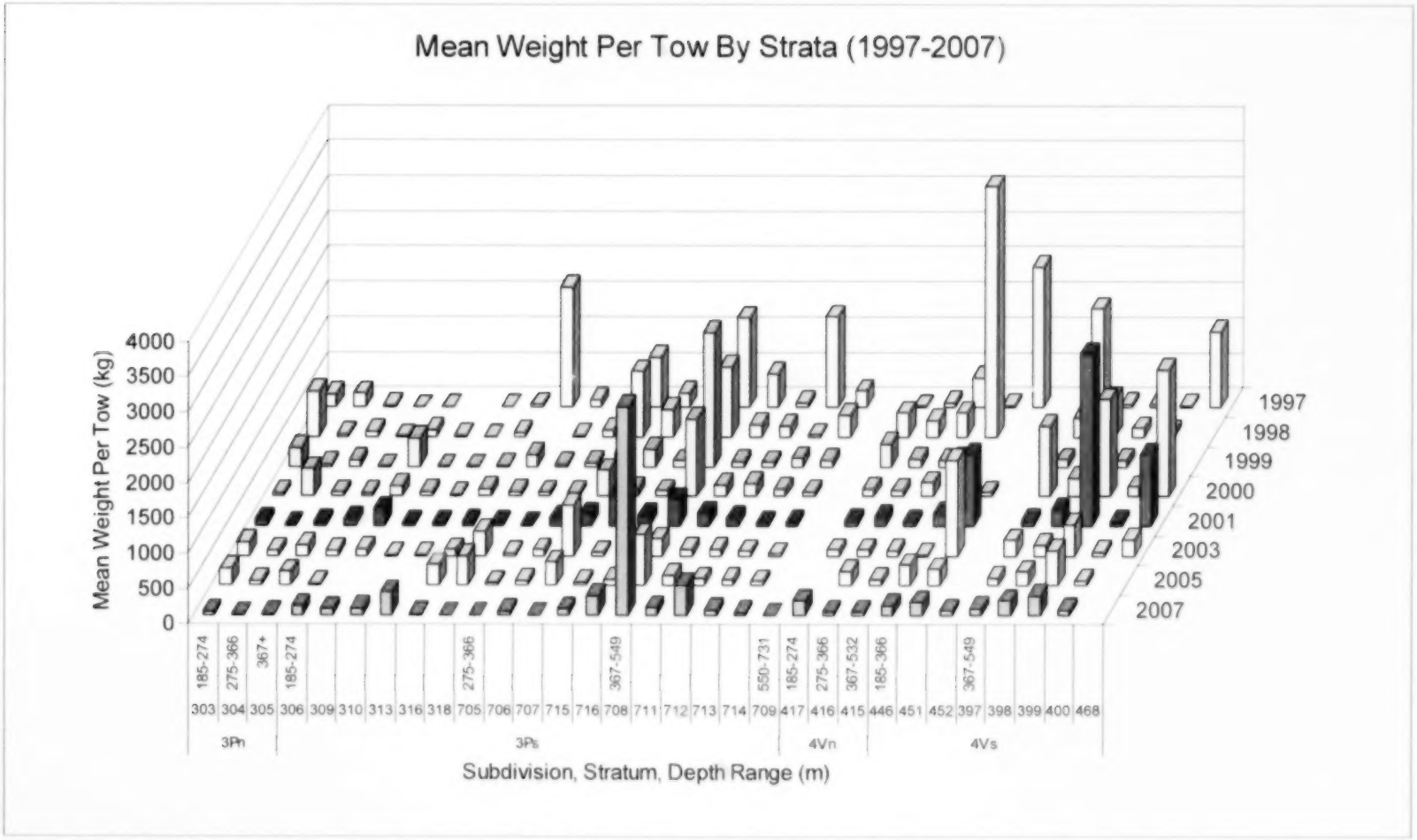


Figure 4. Catch totals of mean weight per tow by subdivision, stratum, and depth range (m).

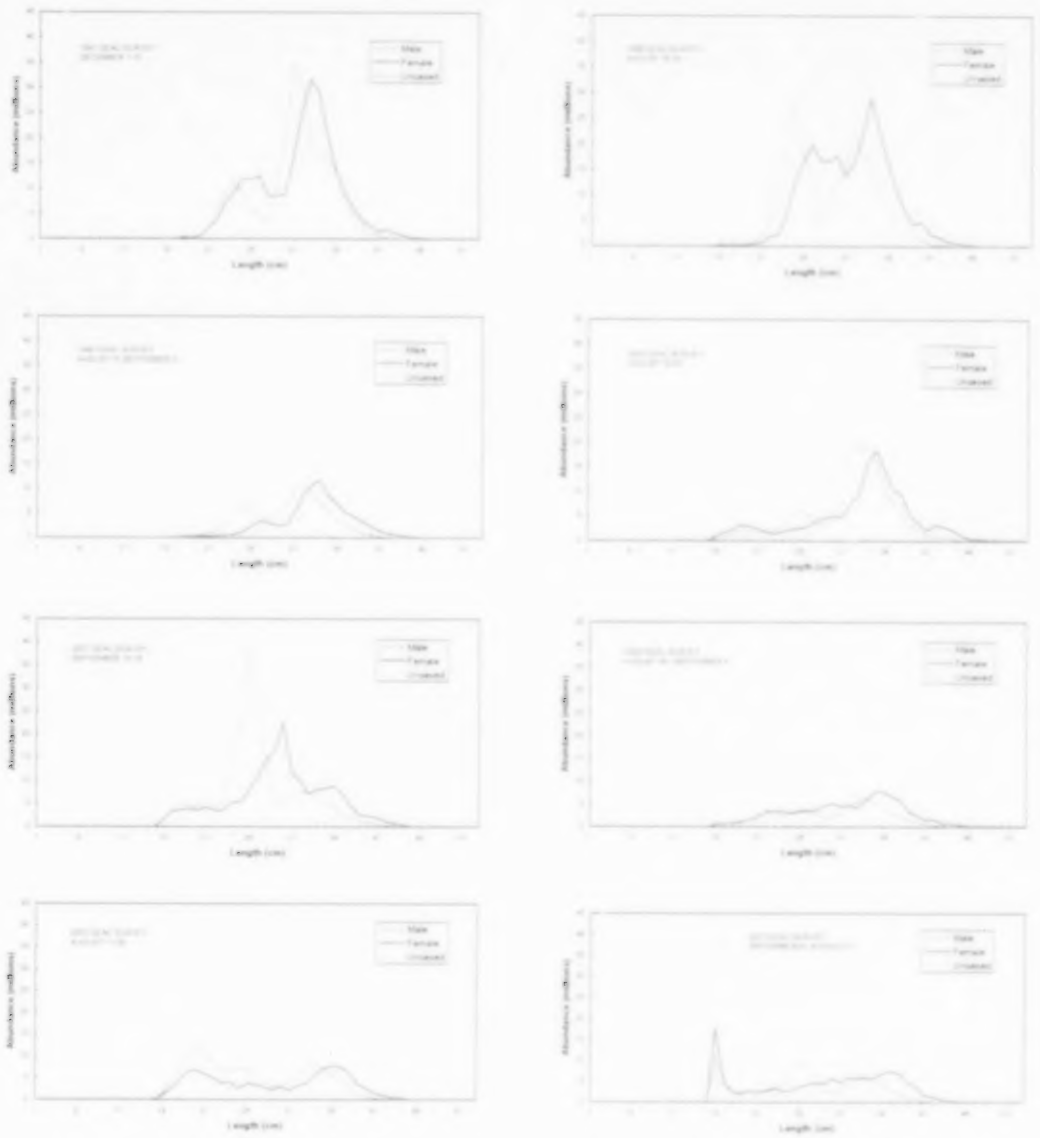


Figure 5. Redfish survey abundance index at length from GEAC industry surveys of UNIT 2 from 1997 to 2007. The 2007 results for unsexed is off the scale but reaches 53 M at length 15 cm.

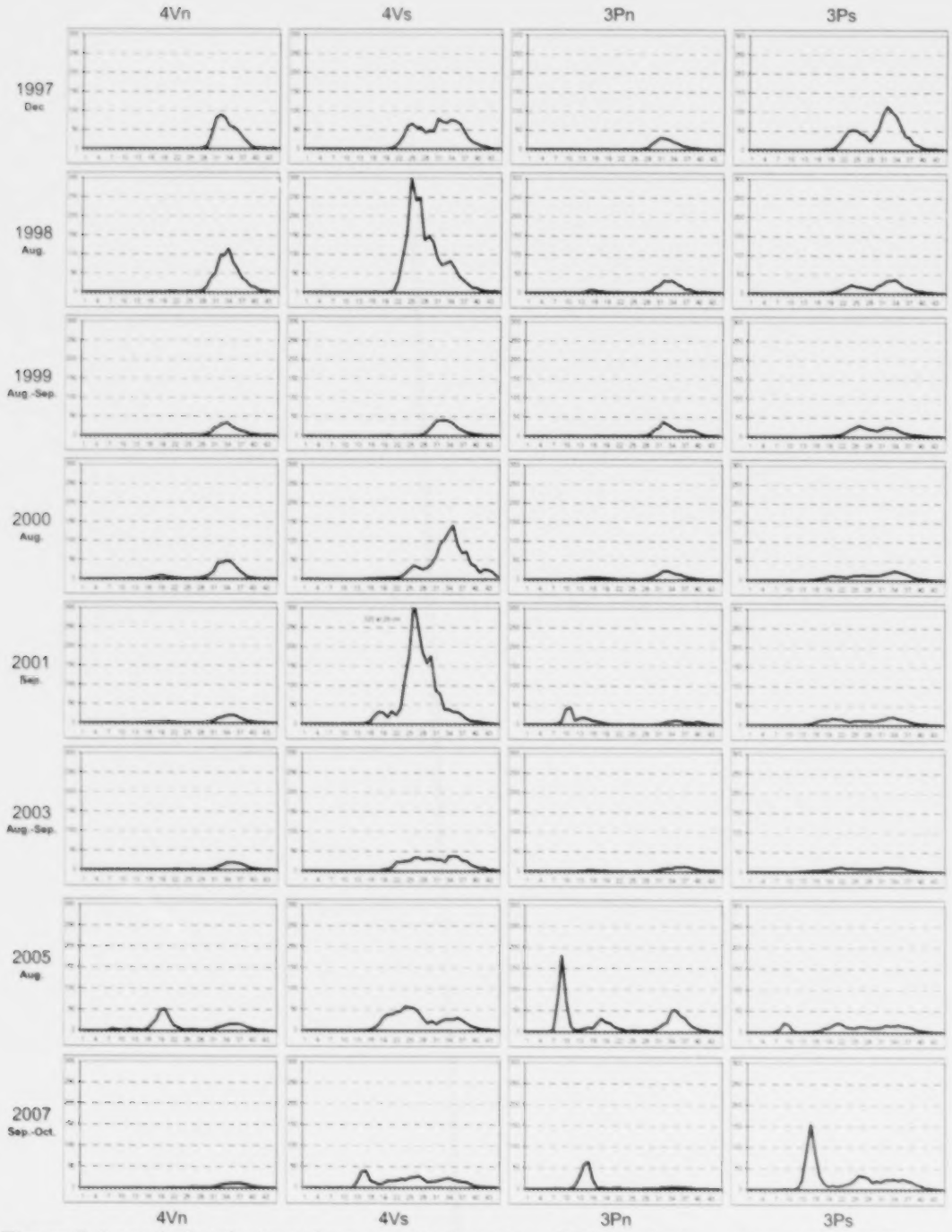


Figure 6. Length distributions from stratified-random GEAC industry surveys to UNIT2 from 1997 to 2007. Plotted are mean number per standard (1.75 n. mi.) tow. X-axis is fork length in centimeters. The 1997, 1999-2000, 2003, 2005 surveys were conducted by the *M.V. Cape Beaver*: the1998, 2001, and 2007 surveys were conducted by the *M.V. Cape Ballard*. All surveys utilized an Engel 170 trawl. The 1997-99 surveys did not utilize a liner.

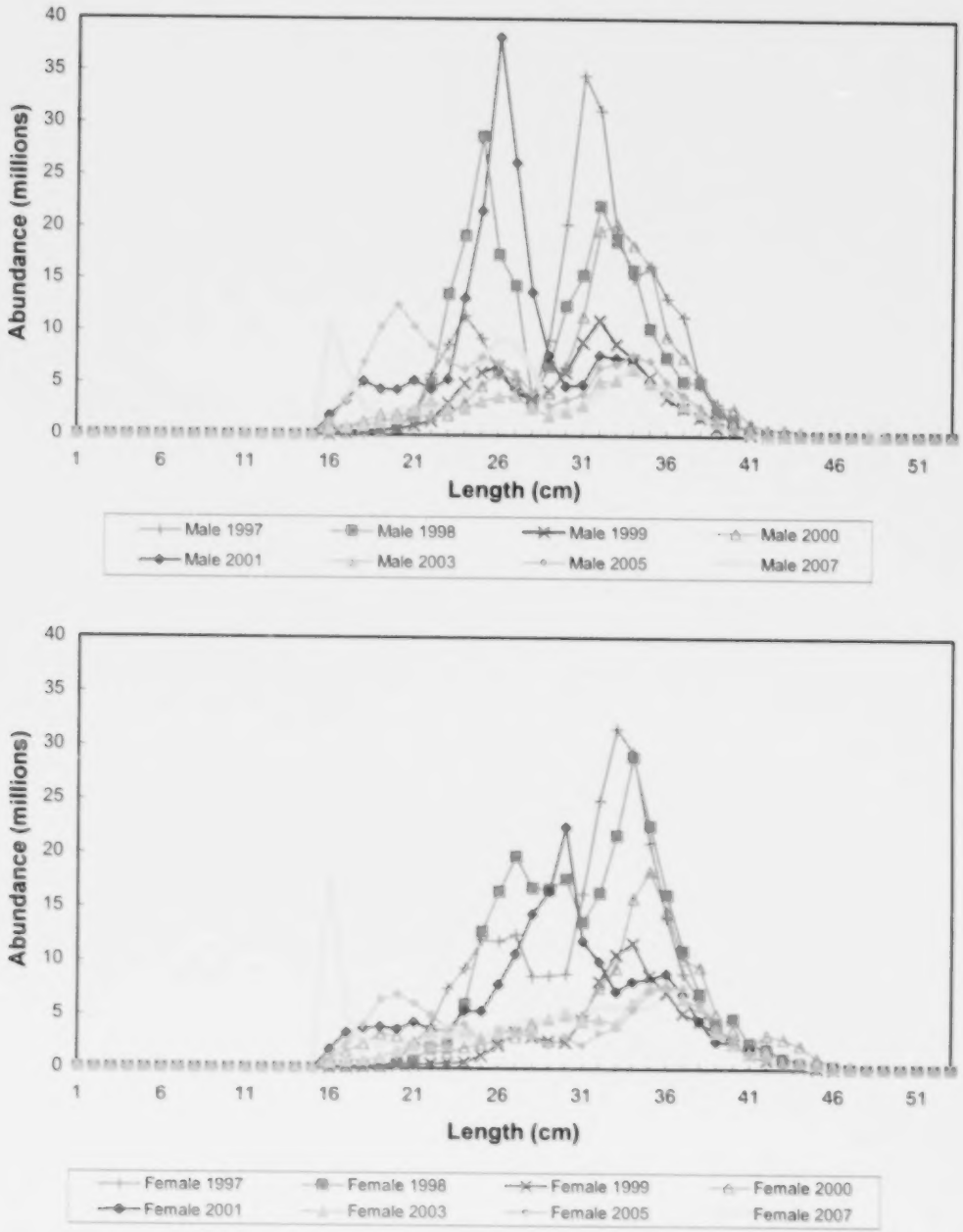


Figure 7. Redfish survey abundance index at length from GEAC industry surveys of Unit 2 from 1997 to 2007. Distributions are shown for male and female populations.

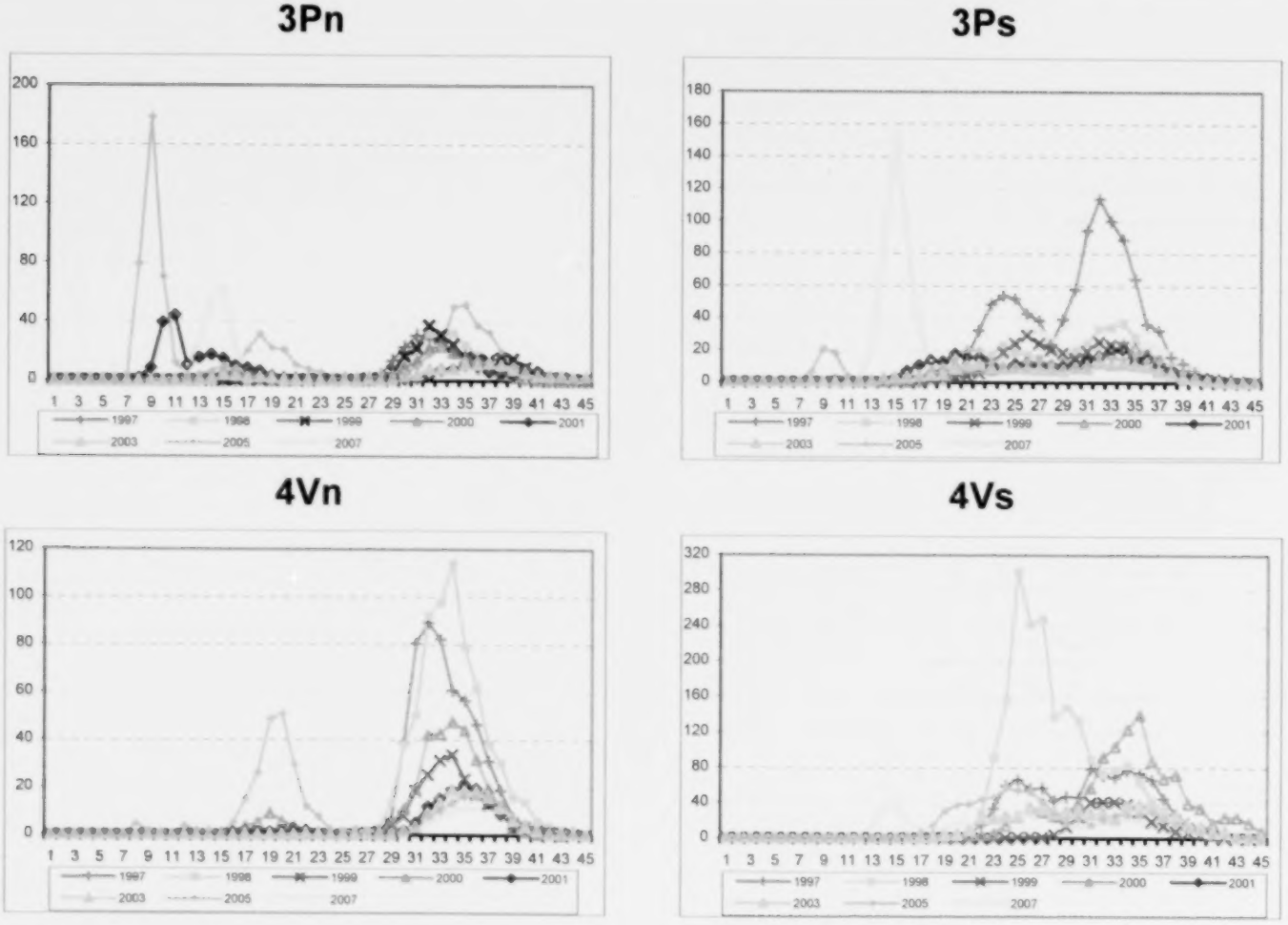


Figure 8. Length distributions as per Figure 3a-c, showing 1997-2007, one panel for each division. Plotted are mean number per standard (1.75 n. mi.) tow. X-axis is fork length in centimeters. Note different y-axis scales.

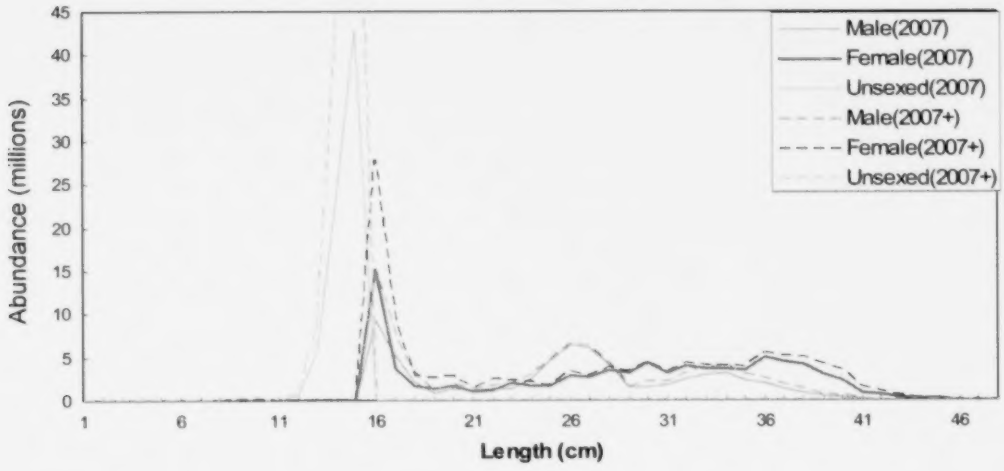


Figure 9. Redfish 2007 survey abundance index at length from GEAC industry surveys of 3Ps. (2007+) includes the additional 3Ps strata 295, 296, 298, 299, and 300.

REDFISH SPECIES COMPONENT ESTIMATES

As part of this survey analysis, a method was put forward to apportion the GEAC 2007 abundance and biomass estimates into species components for illustrative purposes.

The following lengths were used in the breakdown of mature individuals from the 2007/85 paper for Unit 2 (Sévigny et al.) "...The L50 estimated for males and females combined are *S. fasciatus* = 22.5 cm, *S. mentella* = 23.7 cm and heterozygotes = 24.4 cm." This mature component (about 24 cm+) was composed of year classes as they existed around 2002. From an age/length key those year classes would in 2007 be about 29 cm, though in strict terms, there would be additional fish smaller than 24 cm in 2002 that by 2007 (a few more each year) would have become mature, but not yet 29 cm, that are not accounted for in this simplified approach. The estimates of the mature portion are likely an underestimate because of using the 29 cm (27 cm for 2005) as the L50. Nevertheless, two approximations are applied. First, redfish of length 29 cm or greater in 2007 are considered to be mature. For 2005, a length threshold of 27 cm was used. Second, the species proportions from the 2002 "All ages" columns of Table A.1 are applied to the overall (all lengths) abundance estimates as one representation of species proportions.

Following a similar approach, one could apply a length/weight relationship to the abundance estimates, obtain a length distribution for biomass, and apply the same 29 cm (27 cm in 2005) criterion to estimate biomass of mature redfish, all species. Since the "All ages' ratios are associated with abundance it is not appropriate to apply them to the biomass. These results are presented for 2007 and 2005 in Tables A.2 and A.3 respectively. Note that for the biomass there is some error in applying this length/weight relationship. A measure of this is reflected in the last rows of the biomass tables which report the STRAP estimates. In 2007, the "length/weight relationship" estimates for Unit 2 total are 4% less than the STRAP estimates. In 2005, they are about 2% greater than the STRAP estimates.

Under this approach, in 2007 (Table A.2), one third (34%) of the total abundance estimates and three quarters (74%) of the total biomass estimate for Unit 2 are for mature redfish. In regards to the three species population components considered, the 2007 Unit 2 abundance estimate is apportioned as follows: 229 M *S. fasciatus*, 84 M *S. mentella*, and 23 M heterozygotes. Table A.2 presents additional breakdowns of these estimates by subdivision.

The 2007 abundance estimate of 335.7 M is 12% greater than the 2005 estimate of 298.8 M, while the 2007 biomass estimate of 98,366 metric tons is 7% greater than the 2005 estimate of 91,926 metric tons.

For comparison with the survey immediately previous to 2007, Table A.3 presents a breakdown of the 2005 survey using the same approach. In 2005, 43% of the total abundance estimates and three quarters 74% of the total biomass estimates for Unit 2 are for mature redfish. These percentages suggest 9% fewer numbers and about a 5% reduction in biomass for mature redfish in 2007 compared with 2005. In regards to the three species population components considered, the 2005 Unit 2 abundance estimate is apportioned as follows: 204 M *S. fasciatus*, 75 M *S. mentella*, and 20 M heterozygotes.

Table A.1. Indices of abundance of total (all ages) and mature *S. fasciatus*, *S. mentella* and heterozygous redfish for DFO groundfish surveys in Unit 2. (Source: Table 11 of Sévigny et al. 2007).

Survey year	Index of abundance (10^5)					
	All ages			Mature population		
	S. fasciatus	*S. mentella*	heterozygous	*S. fasciatus*	*S. mentella*	heterozygous
1994	565	279	75	225	245	62
1995	445	273	74	131	231	58
1996	322	218	60	149	204	55
1997	535	259	71	238	214	54
2000	578	272	74	253	223	57
2002	561	206	56	226	169	43

Table A.2. Abundance and biomass estimates of *S. fasciatus*, *S. mentella* and heterozygous redfish for GEAC surveys in Unit 2, 2007.

2007

Abundance in millions

	3Ps	3Pn	4Vn	4Vs	Unit 2	% Total
>= 29 cm (mature)	66.9	2.8	18.0	26.0	113.8	33.9
< 29 cm (remaining)	159.8	13.9	1.9	46.3	222.0	66.1
% mature	29.5	17.0	90.2	36.0	33.9	
% remaining	70.5	83.0	9.8	64.0	66.1	
Total	226.7	16.7	19.9	72.4	335.7	

S. fasciatus total	154.5	11.4	13.6	49.8	229.2	68.2
S. mentella total	56.7	4.2	5.0	18.3	84.2	25.0
heterozygous total	15.4	1.1	1.4	5.0	22.9	6.8
Total	226.7	16.7	19.9	73.0	336.3	

Biomass in metric tonnes

	3Ps	3Pn	4Vn	4Vs	Unit 2	
>= 29 cm (mature)	40,109.0	1,786.2	12,234.8	15,410.5	69,540.5	73.8
< 29 cm (remaining)	16,792.9	695.8	446.6	6,727.9	24,663.2	26.2
% mature	70.5	72.0	96.5	69.6	73.8	
% remaining	29.5	28.0	3.5	30.4	26.2	
Total	56,901.9	2,482.0	12,681.4	22,138.4	94,203.7	
STRAP estimates	*59,463.0*	*2,464.0*	*13,412.0*	*23,027.0*	*98,366.0*	

Table A.3. Abundance and biomass estimates of *S. fasciatus*, *S. mentella* and heterozygous redfish for GEAC surveys in Unit 2, 2005.

2005

Abundance in millions

	3Ps	3Pn	4Vn	4Vs	Unit 2	% Total
>= 27 cm (mature)	46.5	20.2	21.3	40.7	128.8	43.1
< 27 cm (remaining)	47.9	35.3	38.4	48.5	170.1	56.9
% mature	49.3	36.4	35.7	45.6	43.1	
% remaining	50.7	63.6	64.3	54.4	56.9	
Total	94.4	55.5	59.8	89.2	298.8	
S. fasciatus total	64.3	37.8	40.8	60.8	203.7	68.2
S. mentella total	23.6	13.9	15.0	22.3	74.8	25.0
heterozygous total	6.4	3.8	4.1	6.1	20.3	6.8
Total	94.4	55.5	59.8	89.2	298.9	

Biomass in metric tonnes

	3Ps	3Pn	4Vn	4Vs	Unit 2	
>= 27 cm (mature)	25,746.5	12,716.5	14,010.1	21,721.8	74,194.9	79.5
< 27 cm (remaining)	5,373.2	1,347.7	4,093.2	8,273.1	19,087.1	20.5
% mature	82.7	90.4	77.4	72.4	79.5	
% remaining	17.3	9.6	22.6	27.6	20.5	
Total	31,119.6	14,064.3	18,103.2	29,994.9	93,282.0	
STRAP estimates	*30,161.0*	*14,092.0*	*18,358.0*	*29,315.0*	*91,926.0*	